S102PRP/S510 MODULE 7 INTO SCIENCE

MODULE 7 LIVING MATERIAL

THE INTO SCIENCE COURSE TEAM:

CHAIRS

Judith Metcalfe

Alison Halstead

GENERAL EDITOR

Judith Metcalfe

AUTHORS

Bob Cordell (Staff Tutor, East Midlands Region)

Dee Edwards (Department of Earth Sciences)

Alison Halstead (Staff Tutor, West Midlands Region)

Judith Metcalfe (Staff Tutor, West Midlands Region)

Dave Williams (Department of Earth Sciences)

EDITOR

Clive Fetter

CONSULTANTS

Mark Atlay (Centre for Science Education)

Stuart Bennett (Department of Chemistry)

Jane Nelson (Staff Tutor, Northern Ireland)

John Walters (Staff Tutor, Wales)

Ruth Williams (Staff Tutor, South West)

OTHERS WHO HAVE HELPED WITH PRODUCTION

Debbie Crouch (Designer)

Perry Morley (Senior Editor)

John Taylor (Illustrator)

FRANCHISE CO-ORDINATOR

Alison Halstead

OTHERS WHO CONTRIBUTED TO EARLIER EDITIONS

Trevor Brown (Part-time Tutor, West Midlands)

Sharon Buckley (Bournville College of Further Education, Birmingham)

Anne Kavanagh (Wulfrun College, Wolverhampton)

Martin Lissenburg (Part-time Tutor, West Midlands)

Claire Nelson (Illustrations consultant)

Gwen Parsons (North Warwickshire College of Technology and Art, Nuneaton)

Nick Studdert-Kennedy (Illustrations consultant)

Peter Turner (Illustrations consultant)

Richard Williams (Part-time Tutor, West Midlands)

The Open University, Walton Hall, Milton Keynes MK7 6AA.

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4.1

STUDY GUIDE

This Module is concerned with the nature of living material and how it differs from non-living, or inanimate, matter. It contains an investigation using yeast that you can carry out in your own kitchen. You will need to purchase some *dried baker's yeast* from a supermarket or health-food shop. Avoid fresh yeast and the newer types of 'easy-blend' or 'easy-bake' yeast, which is mixed directly with flour rather than with sugar and water. You need to set aside two consecutive hours to complete the investigation. Splitting up the time into shorter periods, even if they add up to two hours, will not enable you to carry out the investigation efficiently.

You would find it helpful to check *now* whether you have all the items that you need. These are listed on pp. 3 and 4.

It is important to keep a record of the results of your investigation because they will reveal some of the characteristics of living material. In addition you will need them in order to complete your study of this Module. You learnt in Module 2 that results of practical work have not only to be collected, but also to be presented in a meaningful way so that both you and other people can make use of them. To this end, this Module will introduce you to the value of graphs as a way of presenting data, how to interpret them and how to draw them.

1 MORE ABOUT STUDYING AND LEARNING

All individuals learn in slightly different ways. What is important is that the way *you* learn works for *you*; learning how to learn is therefore part of effective learning.

You were introduced in Module 1 to an important aspect of learning: that it should be active. You were given the opportunity to practise the techniques of highlighting and underlining text and making marginal notes. You were also encouraged to do all the activities, including the practical work provided in the texts. Remember that you are less likely to recall or indeed understand what you have studied, if you read passively.

Earlier Modules introduced you to the technique of summarizing—that is, making brief notes on what you have studied. A summary of a Section helps to identify the most important information and gives you useful feedback on how well you have understood a topic.

This Module includes activities that extend the technique of summarizing sections of text.

A summary should:

- be much shorter than the text that is being summarized
- be easy to read
- contain all the main points
- not include extra information—that is, information not contained in the text that is being summarized.

Note that a summary does not have to give the points in the same order as the original. Nor does it have to be a written summary. You can summarize effectively using diagrams or flow charts, for example.

Another important aspect of learning is to reflect on or think about what you have studied; this is called reflective learning. Reflective learning is better when

it is deliberate—that is, as a conscious structured exercise. The following two points are suggestions that may help you to reflect on your learning.

1 At the start of each study session, spend a few minutes thinking back to what you did last time—this is a useful exercise in recall. You could try to summarize what you studied. Then think about what you plan to do in the current session. Set your target and try to keep to it.

2 At the end of each study session, spend the last few minutes thinking back over what has been covered. Again you could try writing a summary.

These summaries provide useful revision notes, so keep them on cards or in a file for future reference.

To sum up, the technique of summarizing is a useful one, because:

- it helps identify the most important information
- it reveals whether you have understood a piece of text
- it helps you to reflect on your learning
- it provides you with helpful revision notes.

In addition summaries are also important when it is your turn to do the writing, as you will see in Section 8.1.

2 INTRODUCTION

The science that deals with living material is 'biology' (from the Greek *bios* 'life', *-logy* 'study of'). What is living material? All living things share fundamental properties that separate them from non-living material. They have definite structures and they have the capacity to carry out certain activities or processes.

□ Can you think of any activities or processes that are characteristic of living material?

■ You may have thought of one or two of the following (there are others): they require food; most use oxygen; they grow; they reproduce themselves, they excrete waste products, their behaviour is affected by their environment.

Non-living material shows none of these properties. If a pebble is broken in two the two small pebbles that result are not replicas of the original one, whereas living material can produce new individuals that, to a very large extent, are replicas of the original.

From your everyday knowledge you will be aware that living material is very diverse. Living individuals or organisms are divided into a number of groups according to how similar they are. A tree, for example, has several features in common with grass, whereas both trees and grass are quite dissimilar to frogs. Cats share more features with elephants than they do with flowers. In science, trees, grasses, seaweeds and flowers are all grouped together as plants; frogs, fish, cats, giraffes, worms and humans are grouped together as animals.

So far two groups of organisms have been described, plants and animals. However, there are other major groups, one of which is fungi. This includes toadstools, mushrooms, moulds (those that grow on bread, for example) and dry rot. This is the group to which yeast belongs. This Module focuses on yeast, a simple living organism, and investigates its structure and some of its characteristics.

3 WHAT IS YEAST?

First consider its structure. Yeast is very small so to study its structure you would need to use a microscope. You would see that yeast consists of separate round cells, as shown in Figure 1. Each individual yeast cell, or organism, looks identical to its neighbour. A cell is often described as the basic unit of life, because all organisms are made up of cells. Some organisms, such as yeast, are single-celled, but many, such as flowers, insects, seaweeds and humans, are made up of many cells, they are therefore called **multicellular** organisms. You, for example, consist of about 10^{14} cells!

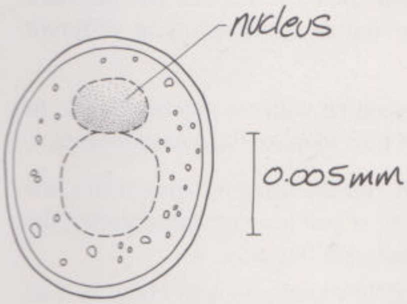


FIGURE 1 A yeast cell.

If a yeast cell was magnified even more, then you could look inside the cell. It contains a number of different structures called **organelles**, each with a definite shape and function. The largest organelle is the **nucleus** (see Figure 1), which plays an important role in the control of the activities or processes characteristic of living material.

You are probably familiar with the fact that yeast is of commercial use. It is used in bread-making where, once added to the dough mixture (flour and water), large quantities of gas are produced which make the dough rise. It is also used in the wine, spirit and beer industry where it is important in alcohol production. If you have ever made wine or beer you will have noticed the gas bubbles that are produced.

The next Section describes an investigation for you to carry out using yeast. In this investigation you will see that under certain conditions large quantities of gas bubbles are produced and in other conditions no gas bubbles or only a few bubbles are produced. Why is this? Having explored the conditions that affect the amount of gas produced, this Module explains the reasons for these observations.

4 SOME CHARACTERISTICS OF YEAST

4.1 INVESTIGATING YEAST

As you read earlier, one of the characteristics of yeast is that it produces gas in beer and bread making. The purpose of this investigation is to examine this gas production. How, for example, does temperature affect the rate of gas production? You will investigate this by putting yeast together with some sugar, into water at different temperatures. You should then observe and measure the amount of gas produced over a period of about 20 minutes. In the investigation you will be collecting both qualitative and quantitative data, two types of results that you learnt about in Module 2.

□ Before going on to carry out the investigation, state clearly what the aim is.

■ The aim is to determine whether temperature affects the rate of gas production in yeast.

METHOD

You will need the following household items:

a heat-resistant and transparent glass or plastic measuring jug that will hold at least 0.5 litres (about 1 pint)

a small pan or kettle

15 cm^3 of sugar (this can be measured with a teaspoon, which is approximately 5 ml, or with a 5 ml spoon as supplied with a bottle of medicine; remember 5 ml is equal to 5 cm^3)

a clock or watch (it only needs to measure minutes)

45 g (about 1.5 oz or 15 level teaspoons) of dried baker's yeast (NOT 'easy-blend' yeast, NOT fresh yeast)

a thermometer (optional); if you do use one, it should be of the type used for jam-making (i.e. it should be capable of measuring from 0 °C to higher than 100 °C).

Note that for this investigation the measurements of sugar and yeast do not need to be precise. What *is* important is that you should use the same quantities at each temperature, since what you will be comparing are results at different temperatures. So, if you begin by measuring, say, a level teaspoon or a rounded teaspoon of sugar in the first investigation, then use this as the standard measurement of the same quantity for the repeat experiments at different temperatures.

Read through all the instructions, before proceeding with the practical work, to make sure that you understand what to do and how to make the measurements.

1 Heat some water until it is lukewarm. If you are using a thermometer, the temperature of the water should be about 37 °C. If you have no thermometer, the water should be neither hot nor cold to the touch, but 'tepid'.

2 While the water is heating, place 15 g (5 level teaspoons or about half an ounce) of the yeast into the measuring jug and add 5 cm^3 (1 teaspoon) of sugar.

3 Pour the warmed water on to the yeast and sugar until the mixture reaches the 150 cm^3 (0.15 litre) mark on the jug, as shown in Figure 2.

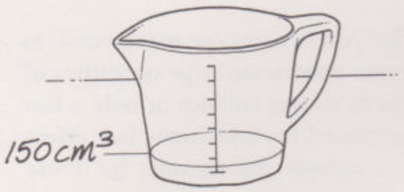


FIGURE 2 Volume of yeast mixture at the start of the investigation.

Note: 1 litre is equal to 1 000 ml (or 1 000 cm^3). If your jug measures in fluid ounces or pints use the table given in Appendix 2 to convert these to cm^3.

4 Gently stir the yeast mixture to dissolve the sugar and disperse the yeast. Once the yeast is dispersed note the time, this is time 0, the beginning of the investigation.

5 Ideally you should leave the mixture in a warm place. Examples include: an airing cupboard, in the oven at a very low temperature or standing in a bowl of water at the required temperature. This is in order to maintain a constant temperature inside the jug. However, when we carried out the experiment, the temperature did not change significantly when left at room temperature.

6 Having completed steps 1 to 5 do the investigation again, but this time use boiling water (100 °C) instead of lukewarm water. Again you should leave the jug in a place that will maintain the temperature at 100 °C.

7 Do the investigation a third time, this time using water straight from the cold tap (about 10 °C). Again try to leave the jug in a place that will maintain a constant temperature.

If you have two jugs you could do steps 6 and 7 at the same time.

□ Ideally, where should you write down your results?

■ In a hardback laboratory notebook (see 'practical work: some useful tips' in Module 2, Section 7).

HOW TO MAKE THE MEASUREMENTS

Qualitative observations Can you see bubbles being formed? If gas is produced you will see bubbles rising to form a layer of froth on top of the mixture of yeast, sugar and water. These changes in the appearance of the yeast mixture are your qualitative observations.

Quantitative observations As the froth holds the gas, measuring the froth gives an approximate measure of the volume of gas produced. You should not stir the mixture while the experiment is in progress as this would affect the amount of froth. Read off the volume every three minutes for 21 minutes; you should therefore make eight readings in total, including the initial reading. When taking the readings you should measure the volume of liquid plus froth to give a total

FIGURE 3 Measure to the top of the froth when taking readings.

volume of the contents of the jug as shown in Figure 3. If the volume lies between markings, measure to the nearest mark in the same way as you learnt in Module 2 when using a ruler. These readings will form the basis of your quantitative observations.

In your notebook draw a table in which to record your results. In case you do not have a notebook, we have supplied a table (Table 1) in which you can enter both your qualitative and quantitative results.

TABLE 1 Your results: quantitative and qualitative measurements of gas production.

Time/minutes	Volume/cm^3 or ml		
	Lukewarm water (37 °C)	Boiling water (100 °C)	Cold water (about 10 °C)
0 (initial reading)			
3			
6			
9			
12			
15			
18			
21			
Changes in appearance after 21 minutes			

Note: In Module 2 you learnt that you should take several readings of each measurement and use the average reading. However, we suggest that in this case you only take one reading at each time interval because there are a number of things you have to concentrate on when doing this investigation. Nevertheless, as you become more practised try to increase your accuracy.

If you have managed to complete the investigation you should have three sets of both qualitative and quantitative results. The following Sections go on to look at these data in detail.

4.2 CHANGES IN APPEARANCE OF THE YEAST MIXTURE: THE QUALITATIVE RESULTS

So far we have carried out the investigation at three different temperatures and put the results in a table. Let us now consider the changes in the appearance of the yeast mixture at the three temperatures—that is, the qualitative observations. Table 2 shows the changes in appearance that we observed in our yeast mixture at the three temperatures. How do these compare with the observations you noted at the bottom of Table 1?

TABLE 2 Changes in appearance of yeast mixture at the three temperatures.

	Lukewarm water (37 °C)	Boiling water (100 °C)	Cold water (about 10 °C)
Changes in appearance after 21 minutes	lots of bubbles on surface, good amount of froth	no change	a few bubbles; some froth

You should have noticed that a large quantity of bubbles collected on the surface of the yeast mixture when lukewarm water was used. (Do not worry if your results were different from ours, it could be for a variety of reasons that are discussed below.)

□ Did the yeast mixture show the same changes when: (a) boiling water, and (b) cold water was used?

■ (a) When boiling water was used no bubbles or frothing was seen. (b) When cold water was used a few bubbles and less frothing was seen than at 37 °C (lukewarm water).

□ What do these observations suggest to you about the behaviour of yeast?

■ In lukewarm water the yeast is active in some way, producing a froth of gas bubbles. At a lower temperature the yeast is less active in terms of gas production, and in boiling water the yeast does not produce gas at all.

In answering this question you were attempting to *interpret* the observations. This is an important skill in science. From the qualitative results of the investigation it is not possible to give a more detailed interpretation. To fully understand the observations it is necessary to know more about the nature of living organisms. However, before discussing that, the next Section examines the quantitative results of the investigation, that is the results that can be measured.

4.3 ILLUSTRATING THE QUANTITATIVE RESULTS OF EXPERIMENTS

Putting the results in a table such as Table 1 enables you to see more easily the changes in the readings *within* a column—that is, all the readings taken at a particular temperature of water. Readings *between* the three columns, at the three temperatures can also be compared.

Table 3 shows a typical set of quantitative results obtained for the yeast investigation. Do not worry if your results are different from these.

TABLE 3 Our quantitative results.

Time/minutes	Volume/cm^3 or ml		
	Lukewarm water (37 °C)	Boiling water (100 °C)	Cold water (about 10 °C)
0 (initial reading)	150	150	150
3	150	150	150
6	200	150	150
9	250	150	150
12	300	150	160
15	370	150	180
18	470	150	200
21	570	150	230

However, another way of displaying scientific results of this type is to plot them on a graph or on several graphs. A graph is a mathematical picture that enables you to see at a glance much more easily what is happening. We have drawn three graphs, one for each set of readings at the three temperatures (Figures 4-6). You can see that the graphs have different shapes. Each shape tells a story—that is, it has a meaning and this meaning can be interpreted. In the next Section you will learn how to draw a graph using your own data.

Figure 4 illustrates the data from the middle column of Table 3, plotted in the form of a graph. The graph, which is drawn on specially designed squared paper, called graph paper, plots the data for the yeast investigation using boiling water.

Before looking at the graph in detail, take a look at the graph paper itself. You can see that it has ruled markings on it. This particular graph paper is 1.0 cm graph paper, because the length and breadth of each of the large squares—that is, those marked with heavier lines—is 1.0 cm.

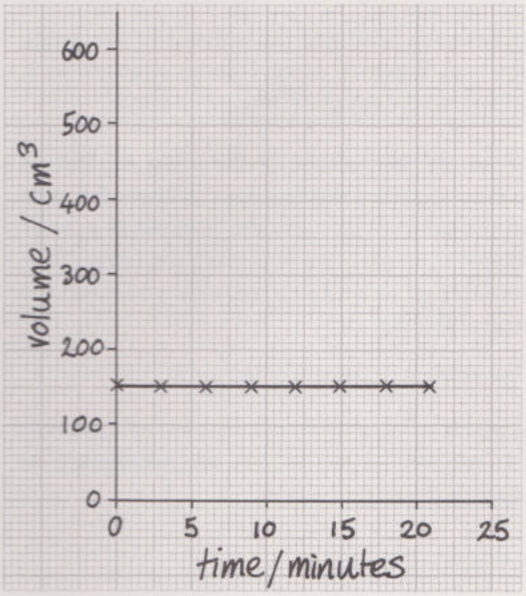


FIGURE 4 Our results using boiling water.

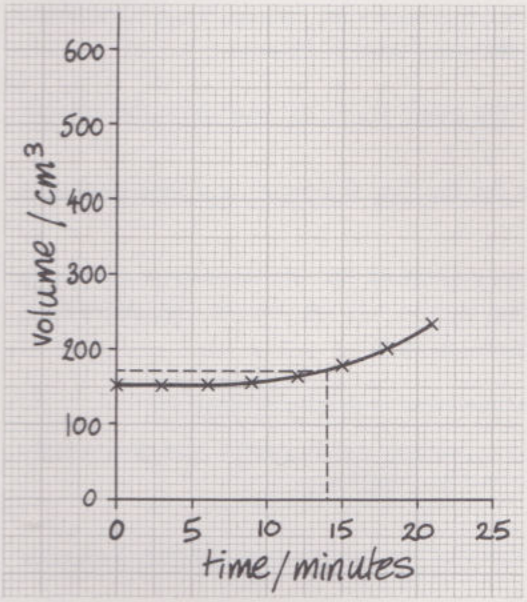


FIGURE 5 Our results using cold water.

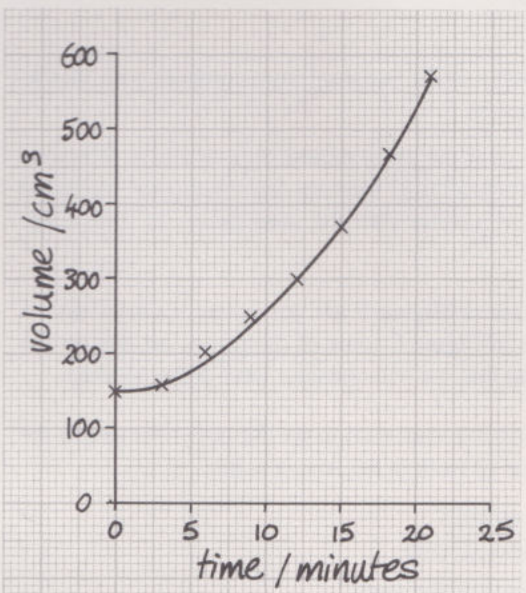


FIGURE 6 Our results using lukewarm water.

SAQ 1 What is the length and breadth of each of the small squares in Figure 4? (You do not need to measure this; try to work it out mathematically.)

There are several features to notice about the graph before a proper interpretation of the data can be made. Two sets of information, or two quantities, are given on the graph. Notice that one quantity is shown along a line going across the page, and the other along a line going up the page. We call these lines **axes** (pronounced axe-eeze; singular: axis). The two quantities are the time at which the readings were taken and the volume of the yeast mixture at that time.

□ Are there any numbers on the axes of the graph that give more details about these two quantities?

■ Yes, there is a range of values for each of the two quantities. For time the range is 0–25 minutes and for volume the range is 0–600 cm^3.

□ What is the most striking feature of the values along a particular axis?

■ The values are uniform along the axis. On the horizontal axis each 0.2 cm represents 1 minute. On the vertical axis 1.0 cm represents 100 cm^3.

This representation is described as the **scale** of the axes; it shows the amount of a quantity that each square represents. It is important that the scale along an axis is uniform otherwise it will lead to wrong interpretations. Thus on the horizontal axis 1.0 cm represents 5 minutes, and this scale is the same all the way along.

The axes tell us that time and volume are connected; that for every value of time, there is a value of volume. Now look at the points that have been plotted on the graph paper. A particular point has two values, one for time and one for volume; its position being determined by the readings given in Table 3. Notice that all the points are joined together to draw a line which is called a graph. What are the values of the second point on the graph in Figure 4? To determine this follow a line from the point downwards until you reach the horizontal axis, then follow a line to the left of the point until you reach the vertical axis.

□ What positions on each axis did you reach?

■ On the horizontal axis, 3 minutes and on the vertical axis, 150 cm^3

Now that several features about the graph have been noted, we can begin to interpret it. The benefit of putting this data on graphs is that it shows at a glance the way in which volume changes with time. The shape of the graph shows you how the values are connected. What does the shape of the graph in Figure 4 mean in terms of these *two* quantities? You can see that the volume of the yeast mixture in boiling water stays the same (150 cm^3) for the full duration of the investigation (21 minutes), and the flatness of the graph is suggestive of nothing much happening.

Now look at the graph in Figure 5, which illustrates the data for the yeast investigation using cold water. Note the axes of this graph before *you* interpret it.

□ Are the two quantities that are connected the same as in Figure 4?

■ Yes, time and volume are connected.

You can see that the relationship between time and the volume of the yeast mixture is different from that shown in Figure 4. Here volume changes with time. All the points are joined together and the resulting graph is a curve.

□ From the graph in Figure 5 read off the volume of the yeast mixture at 14 minutes. (To help you, we have included dashed lines to show the path from a point on each axis to the curve.) Start on the horizontal axis at 14 minutes, follow the dashed line upwards until you reach the curve, then follow the dashed line left, from this point on the curve, until you reach the vertical axis. What is the volume at this point?

■ At 14 minutes the volume of the yeast mixture is $170\,cm^3$.

Note that you have just used the graph to determine the volume of the yeast mixture at a time *between* 12 and 15 minutes. This is called **interpolation**. You could not have done this from looking at the data in a table.

□ At which time did the volume begin to increase?

■ Between 9 and 12 minutes.

Notice that the initial increase occurred at some time between 9 and 12 minutes, but the first reading to register the increase was at 12 minutes.

□ By looking at the shape of the graph try to describe how the volume changes with time.

■ The volume stays the same for the first 9 minutes and then gradually increases with time.

Now turn to Figure 6, which shows a graph of the volume of yeast mixture in lukewarm water (37 °C). Notice that in this graph the same two quantities time and volume are connected as in Figures 4 and 5.

□ Describe the way in which volume varies with time in Figure 6?

■ The volume slowly increases between 0 and 3 minutes, and then rapidly increases for the remaining time of the experiment.

□ How is the difference in the increase in volume before and after 3 minutes shown in the graph?

■ The graph curves gently between 0 and 3 minutes, and then curves steeply upwards.

□ How does the increase in volume of the yeast mixture compare with that in the investigation using cold water?

■ The increase is much greater over the same period of time and is therefore faster. For example, in cold water after 21 minutes the volume has increased to $230\,cm^3$, whereas in lukewarm water after the same period of time it has increased to $570\,cm^3$.

You will notice that all the points in Figure 5 are joined by a curve drawn smoothly between them, whereas in Figure 6 some of the points are not on the curve. This difference is something that we will consider later in the Module.

□ Try to select from the list a possible explanation for the large increase in the number of bubbles and volume of froth in lukewarm water:

1 increase in the size of yeast cells
2 increase in the number of yeast cells
3 production of some material by the yeast
4 production of some gas by the yeast.

■ They are all *possible* explanations. (Based on your qualitative observations about bubbles and froth, 4 seems likely to have the largest apparent effect.)

Further experiments would therefore be required to determine which explanation, or which combination of explanations, is correct. You cannot make firm deductions beyond your observations. Any conclusions you draw must be based on the results of the investigation.

□ What conclusions can you draw about the production of froth from the experiment as a whole?

■ The increase in the volume of froth is affected by the temperature of the water.

In fact there is a small, slow increase at 10 °C, a larger, faster increase at 37 °C and no increase at all at 100 °C. There is a biological interpretation of these observations in Section 6, but before that let us take a look at your own quantitative results and how to plot them on a graph.

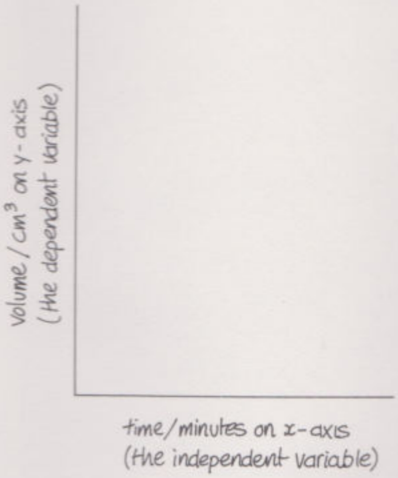


FIGURE 7 The axes of your graph.

5 PLOTTING THE RESULTS ON A GRAPH

Having learnt about the axes and scales of graphs, and how to interpret graphs, this Section goes on to explain the mechanics of how to plot graphs. To do this you will need a sheet of graph paper (overleaf), a sharp pencil, a rubber and your own experimental data.

We plotted our data on to three sets of axes—one for each temperature (Figures 4–6). We suggest that you plot all three graphs on to the same set of axes so that you can compare their shapes at a glance. The following exercise in graph-plotting is divided into a number of steps.

GUIDED EXERCISE 1: PLOTTING EXPERIMENTAL DATA

Step 1 *Choosing suitable axes*

You have two kinds of readings, time and volume; you therefore need to decide which one to put on which axis. The time intervals, in this investigation, were decided before the investigation began—that is, they were fixed. Such fixed information—termed the **independent variable**—is plotted on the horizontal axis which conventionally is called the x-axis. However the volume readings were dependent on the time you took the readings and consequently are termed the **dependent variable**. Such quantities which are dependent on other variables are plotted on the vertical axis which conventionally is called the y-axis. Figure 7 summarizes this information.

Step 2 *Drawing the axes*

You have seen that graphs are usually drawn on graph paper. All the graph paper you have seen so far in this Module is 1.0 cm graph paper.

The size of the graph paper helps us to work out the scale on each axis as well as the orientation of the graph on the paper (illustrated in Figure 8).

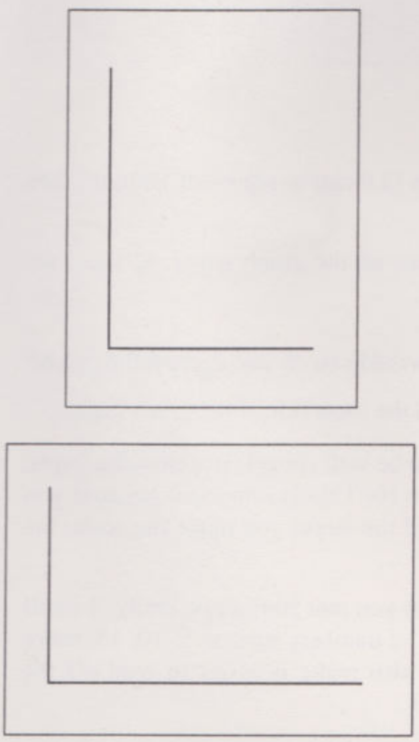


FIGURE 8 Orientation of the graph on the graph paper.

We suggest that you use the whole sheet of graph paper to plot your axes (Figure 9). Look at the range of readings for our data. The values for time vary from 0 to 21 minutes and those for volume from 150 cm^3 to (about) 600 cm^3. Your values for volume may differ from ours so you need to bear this in mind. What would be suitable scales to choose for our data? Note that the scales on the x and y axes do not have to be the same.

For time if you choose two large squares (2.0 cm) to represent 5 minutes, then to represent 21 minutes you need 9 squares.

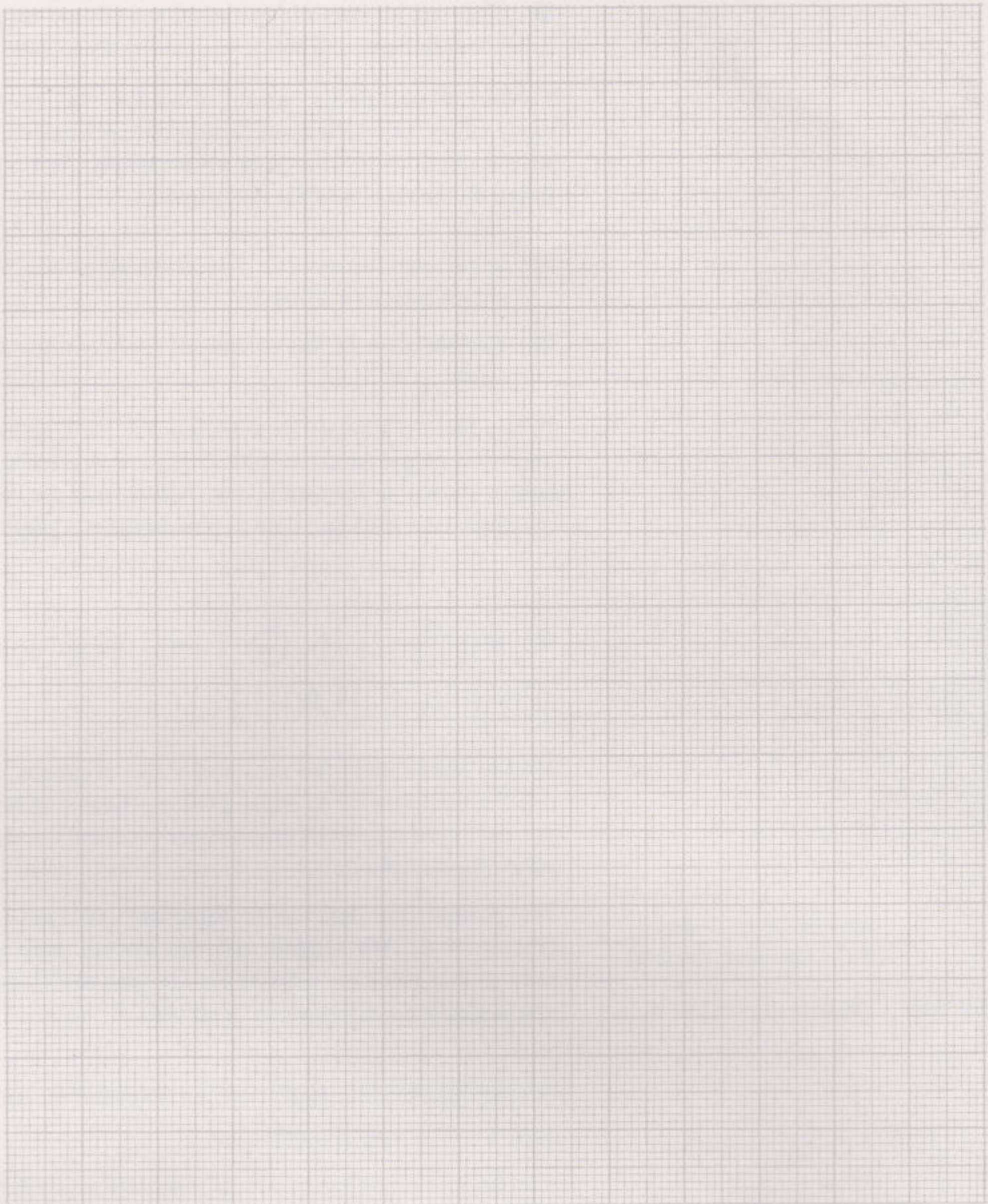


FIGURE 9 Graph paper for your experimental results.

For volume if you choose two large squares (2.0 cm) to represent 100 cm^3, then to represent 600 cm^3 you need 12 squares.

There are 13 squares across and 16 squares up the graph paper, so these are reasonable scales to use.

□ Given these readings what orientation would you choose to draw the graph?

■ The horizontal axis should be drawn on the short side of the graph paper.

The divisions on the axes allow the points to be well spread out across the paper, not cramped up in one corner, as in Figure 10. This is important because you want to read off values from the graph, and the larger you make the scale, the easier this is.

You should also choose a scale that will help you plot your graph easily: 4 small squares represents 1 minute. The sequence of numbers such as 5, 10, 15, make plotting points more straightforward and also make it easier to read off the points of the scale in between these numbers.

Draw the axes on the graph paper. There is special point at which the value on both the axes is zero (see Figures 4–6). This is called the **origin** and can be

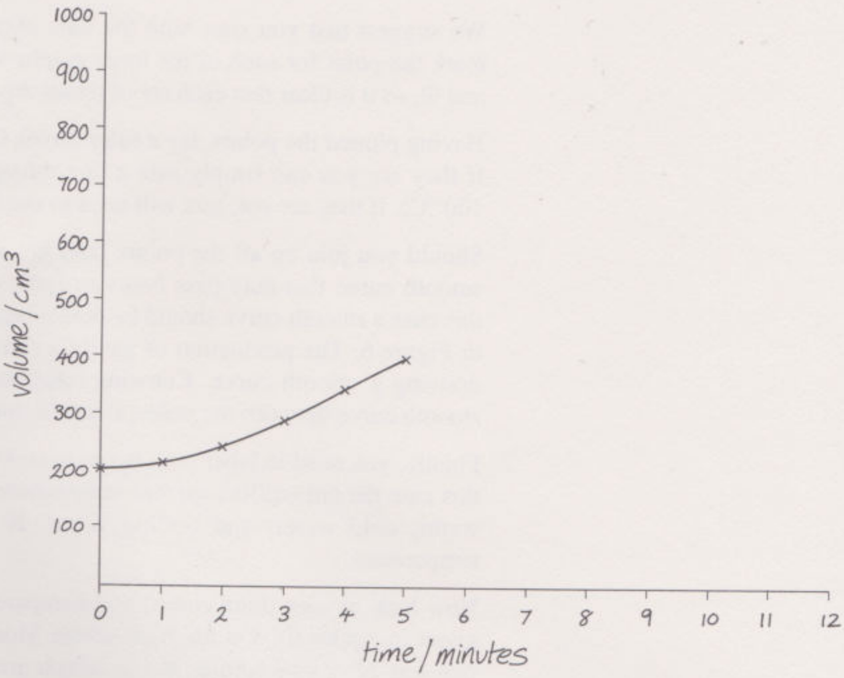


FIGURE 10 An example of an inappropriate scale.

thought of as the starting-point for each axis. Write in the quantities on each axis, remembering to keep the spacing uniform—that is, for every 2.0 cm along the x-axis the unit of time should increase by 5 minutes. Write the values alongside the line, for the y-axis, as illustrated in Figures 4–6.

Step 3 *Labelling the graph*

For a graph to convey meaning to others it must be completely labelled in a similar way to the conventions used in Module 2 to label the headings of tables. First, label the axes with the quantities or **variables** (time or volume), followed by a slash (/) which in turn is followed by the units (minutes or cm^3). Second, give the graph a title. This should include information about the content of the graph; for example the words 'yeast mixture' would need to be included. In addition, the title should include some information about temperature, such as 'at different temperatures'.

□ Can you think a of suitable title?

■ Here are some suggestions: 'The volume of yeast mixture over time at different temperatures'; 'Graphs to show the variation with time in the volume of gas produced by yeast at different temperatures'.

> A graph requires:
> - a title (description of the data)
> - axes (labelled with variables/units)
> - scales (numbers along axes).

Step 4 *Putting data on to the graph*

Now plot the points for each of the three graphs in turn. To plot a point you follow the same procedure that you used to read a point in Figure 5, p. 7. Suppose you have a reading of 200 cm^3 at 18 minutes. Follow up the vertical line from 18 minutes and along the horizontal line from 200 cm^3 Where these two lines meet you should draw the point. Conventionally each point on the graph is described by first giving the horizontal value, and then the vertical value, with both numbers enclosed within brackets, for example (18 minutes, 200 cm^3). If you would like more practice at plotting points turn to SAQ 8 at the back of the Module.

We suggest that you start with the data obtained using boiling water. You should mark the point for each of the three graphs with a different mark, for example +, × and ⊕, so it is clear that each set of points represents a different experiment.

Having plotted the points, lay a ruler across them to see if they are on a straight line. If they are you can simply rule a line through them all (for example, your data at 100 °C). If they are not, you will need to use the individual points to get a curve.

Should you join up all the points (and get an uneven curve) or should you draw a smooth curve that may pass *between* some of the points, as shown in Figure 6? In this case a smooth curve should be drawn (using a flexicurve if you prefer), as shown in Figure 6. The production of gas is a continuous process, and we reflect this by drawing a smooth curve. Knowing whether to join up all the points or to draw a smooth curve between the points is a skill that develops with practice.

Finally, you need to label each curve to make clear the differences between them. In this case the only difference was temperature, so suitable labels would be: lukewarm water; cold water; and boiling water. If you used a thermometer specify the temperature.

Now look at your three curves and compare them with ours in the specimen graph given in Appendix 3 at the back of the Module (Figure 20). In which ways are the two sets of graphs similar and in which are they different? Clearly any difference reflects differences between the results of the investigations.

□ Are your results different from ours? If so, try to suggest reasons as to why your results might differ from ours.

■ The two sets of results might differ because of differences in:

- the temperature of the water
- the initial quantities of water, sugar or yeast
- the uncertainty of the readings or inaccuracy of the scale on the measuring jug
- the activity of the yeast cells.

You might have thought of other reasons as to why your results differ from ours.

Look at Figure 11, which illustrates another useful feature of graphs. A graph can reveal an anomalous result as a reading which doesn't easily fit into the general pattern of results. This could result from an error in arithmetic or a mistake when taking or plotting the reading.

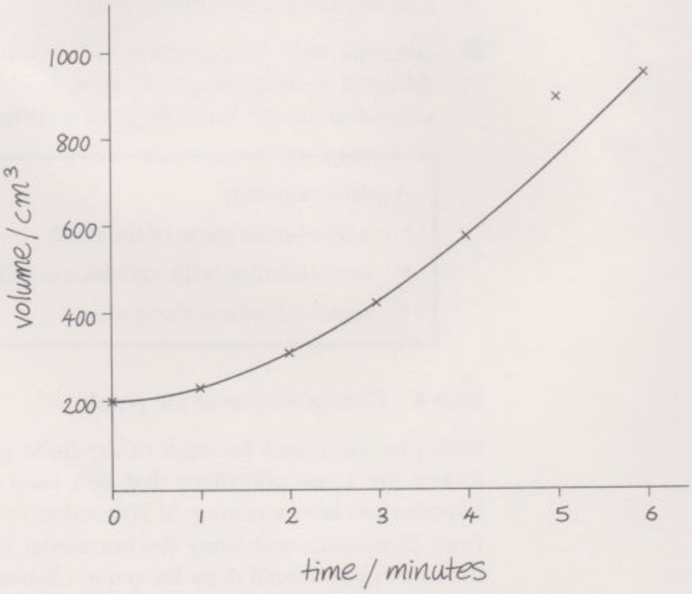


FIGURE 11 A graph with a possible anomalous result at 5 minutes.

This Section has shown you how to plot data on a graph. It is important to remember that for a graph to convey meaning to others it needs to be carefully labelled.

6 EXPLANATION OF THE RESULTS OF THE INVESTIGATION

So far you have carried out the investigation using yeast, collected the results and presented them in tables and on graphs. The results of the investigation showed that most bubbles appeared on the surface at the lukewarm temperature. This observation suggests that the yeast is most active in some way at around 37 °C. Why do yeast cells produce bubbles of gas? What is this gas? Why is the quantity produced affected by temperature? This Section explains the biology behind these observations. It is important to note that you could not derive these explanations from the observations of your investigation.

All living things need energy to survive and maintain themselves. The idea that food provides energy is often used in advertisements for chocolate and breakfast cereal. You, for example, need energy to carry out activities and maintain your body from day to day. This is one of the important characteristics of living material that separates it from non-living matter.

□ Can you suggest any activities that you carry out each day which involve the use of energy by our bodies?

■ You might have thought of some of the following (but there are many others): movement of muscles; heartbeat; thinking, and other activities using the nerve cells.

Yeast also needs energy to survive and maintain itself.

□ Where do you think the yeast in the investigation gets its food and therefore its energy from?

■ From the sugar.

Sugar is the only carbon compound dissolved in the mixture and since organisms are made largely of water and compounds of carbon (Modules 5/6), it would be reasonable to assume that the yeast have used the sugar for growth and have transformed it into their own mass. Yeast naturally live in situations where sugar is readily available, such as in the nectar of flowers, and on the surface of fruit. You can see them on the surface of healthy grapes or sloes, for instance, where they contribute to the grey film.

The process by which energy is released from food such as sugar is called **respiration**. You may be surprised to learn that in biology the term respiration means the chemical breakdown of foods to release energy. In everyday life the word is often used to describe the process of taking gases into and out of the body (breathing).

Depending on the environmental conditions, yeast cells carry out one of two kinds of respiration. One depends on the reaction of food chemicals, such as sugar, with oxygen to release energy. This is called **aerobic respiration**. The other depends on the breakdown of food chemicals without oxygen being involved at all. This is called **anaerobic respiration** or fermentation. In both types of respiration, the gas carbon dioxide is produced. The bubbles and froth that appeared on top of the yeast mixture were carbon dioxide, the product of yeast respiration.

Let us look at the process of respiration inside the yeast cell in more detail, in order to understand the results of the investigation you carried out. Begin by concentrating on what was happening in the investigation at 37 °C. Sugar molecules are taken into the yeast cell where they are broken down to release energy. At the beginning of the investigation there would be some oxygen dissolved in the water which the yeast cells would be able to use for aerobic respiration. As long as oxygen is available, yeast cells respire aerobically to break down the sugar molecules to carbon dioxide and water.

A word equation can be used to summarize the chemical reaction of aerobic respiration:

sugar and oxygen goes to carbon dioxide, water and energy

The above equation can be written as a chemical equation (although you need not remember the detailed structure of the molecules):

$$\underset{\text{one molecule of sugar}}{C_6H_{12}O_6} + \underset{\text{+ oxygen}}{O_2} \xrightarrow{\text{yeast}} \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{+ water}}{H_2O} + \text{energy}$$

Note that an arrow is often used in these sorts of biological equations instead of the equals sign, and means 'goes to'.

□ The equation above is not balanced; can you balance it as you learnt in Module 5, so that there are equal numbers of atoms on each side?

■ $$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{yeast}} 6CO_2 + 6H_2O + \text{energy} \quad (1)$$

Equation (1) is the basic equation for aerobic respiration.

In a relatively short period of time after the start of the investigation, in fact only a few minutes, the oxygen in the water would have been used up and the developing froth on top would prevent any further oxygen dissolving from the air into the mixture. At this point the yeast cells would switch to anaerobic respiration. Again, the sugar is broken down but this time its remains are released as carbon dioxide and alcohol. If you had left the investigation for a longer period of time, you would have begun to notice the smell of ethanol, the common term for which is alcohol (whisky, for example, contains 40% ethanol). Because of this remarkable property of yeast to respire anaerobically and produce alcohol, yeast is important in the wine, spirit and beer industry.

A word equation can be used to summarize the chemical reaction of anaerobic respiration:

sugar gives carbon dioxide and ethanol and energy

This equation can be written as a chemical equation:

$$\underset{\text{one molecule of sugar}}{C_6H_{12}O_6} \xrightarrow{\text{yeast}} \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{+ ethanol}}{C_2H_6O} + \text{energy}$$

□ The above equation is not balanced. Can you balance it?

■ $$C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2CO_2 + 2C_2H_6O + \text{energy} \quad (2)$$

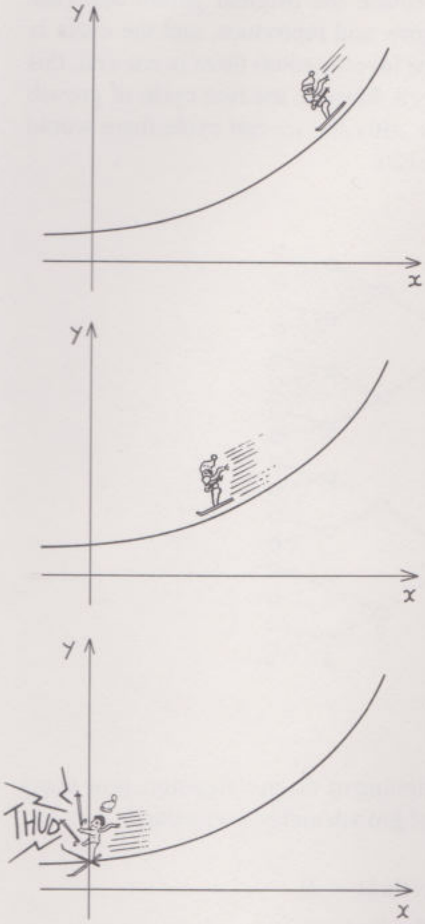
Equation (2) is the basic equation for anaerobic respiration in yeast.

Thus because yeast cells can carry on respiring even in the absence of oxygen, carbon dioxide bubbles continue to be produced and consequently the volume of froth increases.

In contrast to aerobic respiration where the sugar molecule is completely broken down to water and carbon dioxide, in anaerobic respiration the breakdown is less complete. The consequence of this is that less energy is derived from anaerobic respiration than aerobic respiration. Therefore as long as oxygen is available, the yeast cells respire aerobically ensuring the greatest production of energy. If you had bubbled air through the yeast mixture, or constantly shaken the jug, the yeast would have continued to respire aerobically.

These chemical equations, 1 and 2, like all the others you have met (see Modules 5/6), involve the conversion of chemicals to new compounds without

loss of material. Energy is produced as a by-product of these reactions. In fact all chemical reactions either use up or give out energy.



Every graph tells a story!

You can now understand the origin of the gas bubbles produced in the investigation, but why should different volumes of carbon dioxide be produced at different temperatures? Is temperature affecting the rate of respiration in some way? The answer to this question requires a deeper understanding of the process of respiration.

The conversion of many chemical compounds into new compounds is assisted by substances called **enzymes**. Enzymes are found in all living material and have the important property of speeding up chemical reactions, without themselves being used up or changed in any way; they are used over and over again. Without enzymes, the chemical reactions on which living material vitally depend, would occur very slowly—too slowly for survival.

A crucially important point is that the activity of enzymes is affected by temperature. The effect of temperature on enzyme activity explains the difference in the quantity of gas produced in the yeast investigation. The enzymes in yeast, like many others, work best at about 37 °C, a temperature that results in the rapid breakdown of sugar and the high rate of production of CO_2 bubbles.

At lower temperatures enzymes do not work so well. Consequently the breakdown of sugar occurs more slowly. Thus in the investigation using cold water fewer bubbles were produced. At very high temperatures the structure of the enzymes is permanently damaged, so that they can no longer function; the yeast cells therefore die. This explains the results observed when boiling water was used: no breakdown of sugar occurred and no bubbles of CO_2 were produced.

One final point. The yeast that you have used has been artificially dried to increase its keeping quality. Such drying is also used to allow storage of pulses such as beans and lentils. The removal of the water stops the enzymes working. In order for the enzymes to function, yeast needs to take in water.

SAQ 2 Try to summarize Section 6 *in your own words* in three or four sentences. Include the following biological terms in your summary: aerobic respiration, anaerobic respiration and enzymes. You need not produce details of the equations in this summary.

7 GROWTH AND REPRODUCTION

Earlier Sections looked at the differences between the amount of gas produced at three temperatures and presented the results in graphs. By comparing the shape of one graph of one set of results at a particular temperature with that of another you could see at a glance the differences in the results. This Section looks at how one particular graph changes shape along its curve.

After adding the lukewarm water to the yeast and sugar the dried yeast cells take in water and the enzymes begin to function. With time the cells would begin to grow using energy to do so; each individual cell grows until it reaches its maximum size.

If you were to leave the yeast mixture with plenty of sugar and other nutrients required for growth, in an incubator at 37 °C for a few days, the yeast cells would reproduce. The ability of yeast cells to reproduce themselves involves using chemical compounds such as sugar and converting them into new compounds such as those required to build organelles (Figure 1). So you will not be surprised to learn that the process of **reproduction** like growth, requires energy.

Yeast cells reproduce by splitting into two in a complex series of changes called **cell division**. The process of cell division involves the nucleus. A cell without a nucleus is unable to reproduce. The result of cell division is two identical offspring (called progeny cells), which replace the original parent cell (see Figure 12a). These progeny cells in turn grow and reproduce, and the cycle is repeated. Thus if at time zero (the start of the investigation) there is one cell, this represents the first **generation**; following cell division, the first cycle of growth and reproduction, there would be two cells; after the second cycle there would be four cells, and so on, as shown in Figure 12b.

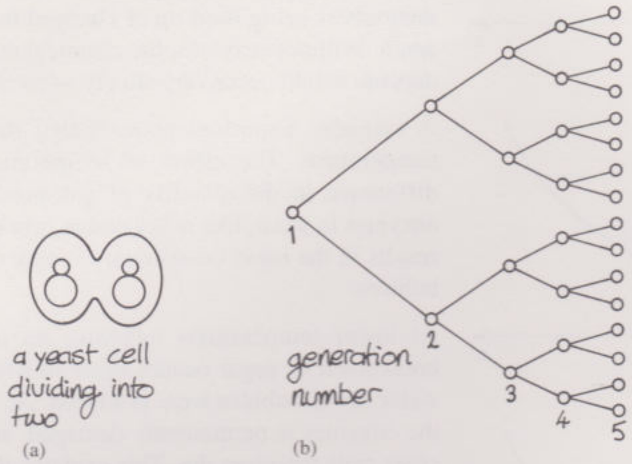


FIGURE 12 Reproduction of yeast cells.

□ Suppose there were one cell at the beginning of the investigation, how many cells would there be after four cycles of growth and reproduction?

■ After the first cycle there would be 2 cells (1×2)
after the second cycle there would be 4 cells (2×2)
after the third cycle there would be 8 cells ($2 \times 2 \times 2$)
and after the fourth cycle there would be 16 cells ($2 \times 2 \times 2 \times 2$).

This series can be expressed in a mathematical way, using powers. You met these in Module 4, where you learnt that 10^2 equals 10×10, or 100, and that 10^3 equals $10 \times 10 \times 10$, or 1 000.

In the above series the number of yeast cells doubles in each generation—that is, after every cycle of growth and reproduction; so

$2^2 = 2 \times 2 = 4$ and

$2^3 = 2 \times 2 \times 2 = 8$

Here the powers represent the number of cycles of growth and reproduction.

□ How many cells would there be after four generations?

■ $2^4 = 2 \times 2 \times 2 \times 2 = 16$

You can do this kind of calculation quickly on your calculator using the x^Y key. On some calculators this key is denoted as y^X; check yours now! Here we shall refer to it as the x^Y key. Instead of carrying out the calculation $2 \times 2 \times 2 \times 2$ you can convert 2^4 directly using the x^Y KEY.

Follow the procedure given in Box 1 to convert 2^4 to a whole number.

BOX 1

Press 2
press x^Y
press 4
press = (16 should appear)

TABLE 4 Number of yeast cells after each cycle of growth and reproduction.

Number of cycles of growth and reproduction	Number of yeast cells
1	2
2	4
3	...
4	...
5	...
6	...
7	...
8	...
9	...

SAQ 3 Complete Table 4, using the x^Y key to give the number of yeast cells after each cycle of growth and reproduction, up to and including the ninth cycle. *Check your answers with those at the back of the Module before proceeding.*

Figure 13 is a graph of the number of yeast cells after each cycle of growth and reproduction, using the data given in the answer to SAQ 3.

Look at the shape of the graph. For each cycle of growth and reproduction the graph becomes steeper and steeper. This type of increase in the number of yeast cells has a particular term to describe it: **exponential growth**. Exponential growth describes growth where a quantity increases by a fixed factor (in this case, the population doubles) in a given interval (in this case, successive generations).

The graph in Figure 13 could illustrate exponential growth for a population of any organism, including beetles, birds and human beings. Of course, organisms such as these would take a lot longer than yeast to double their population size! Growth of this type, however, can continue only for as long as there is a plentiful supply of food.

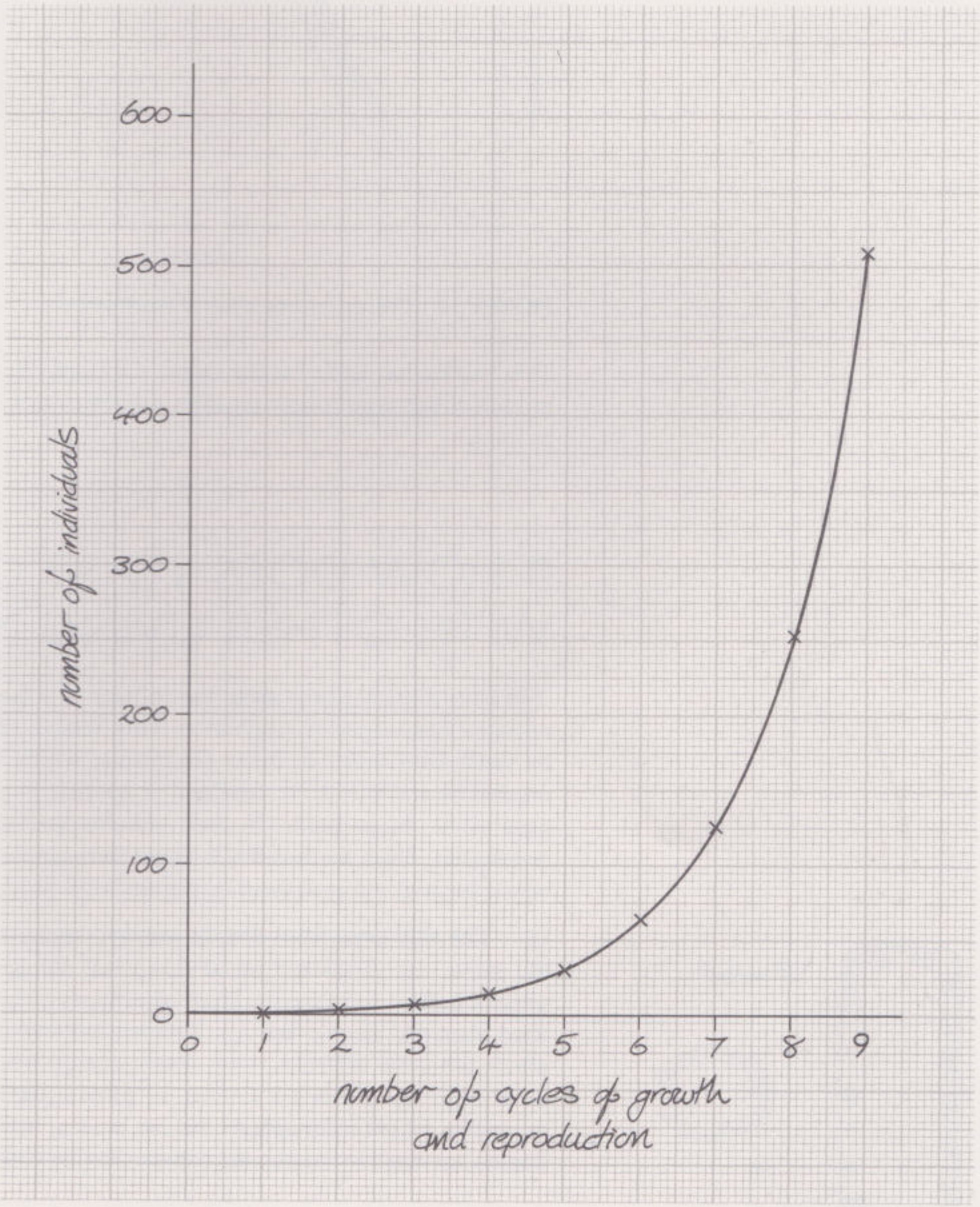


FIGURE 13 Number of yeast cells after each cycle of growth and reproduction.

□ What would happen to the size of the population of yeast once the food supply was exhausted?

■ It would stop increasing and then would begin to decline.

□ How would this affect the shape of the graph?

■ The curve would become less steep as growth slowed down, then level off where the number of individuals stayed the same and then turn downwards where the numbers decreased. These changes in the profile of the graph are shown in Figure 14.

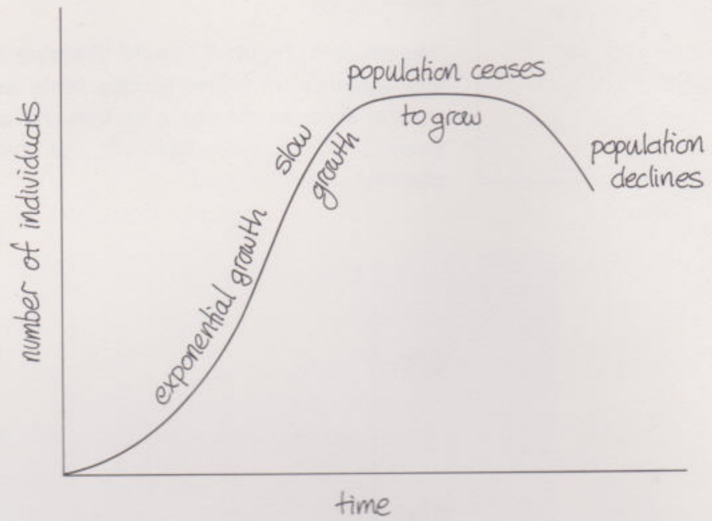


FIGURE 14 Change in population of yeast with time.

This Section has looked at the shape of a graph of exponential growth. However, growth of this type is only possible as long as there are plenty of resources such as food.

8 HOW DOES YEAST COMPARE WITH OTHER LIVING MATERIAL?

You have already learnt about the cellular structure of yeast and how energy is released from sugar by respiration. This Section compares some of the features of yeast with those of other organisms; which features are common to all organisms and which are confined or specific to yeast? It looks at (a) the way organisms obtain food, (b) their cellular structure and (c) their method of respiration. There are two SAQs about summarizing at the end of Section 8.1; it would be useful to read them before studying Section 8.

(a) **The way organisms obtain energy.** Organisms do not all obtain energy in the same way. Section 6 noted that yeast obtains energy from sugars (food) present in fruit and flowers. Most other types of fungi, however, feed mainly on dead plant and animal remains. Animals too feed on other organisms. However, plants are quite different: they obtain energy from sunlight and produce their own sugar by a process known as **photosynthesis**. This occurs in green organelles called **chloroplasts** that are present inside plant cells (see Figure 15). Sugars are made by combining carbon dioxide with hydrogen from water.

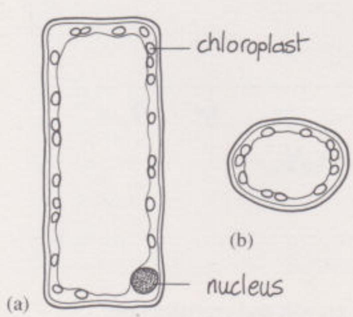


FIGURE 15 A plant leaf cell: (a) cut lengthways; (b) cut across.

□ Re-read the previous sentence and try to determine, from the structure of the molecules, what must be the other product of the process of photosynthesis.

■ Oxygen.

The equation can be written:

$$CO_2 + H_2O \longrightarrow C_6H_{12}O_6 + O_2$$

□ Can you balance the above equation?

■ $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

The energy needed to make sugars (and other substances) is obtained by trapping sunlight in the chloroplasts. You should not be surprised to learn that it too is assisted by enzymes, although these are different from the ones involved in respiration.

$$6CO_2 + 6H_2O \xrightarrow{\text{sunlight}} C_6H_{12}O_6 + 6O_2 \qquad (3)$$

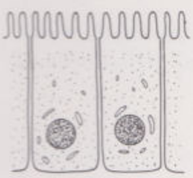
Equation (3) is the basic equation for photosynthesis.

Interestingly, the efficiency of photosynthesis is about 2%—only 2% of the light energy is converted by plants into carbon compounds.

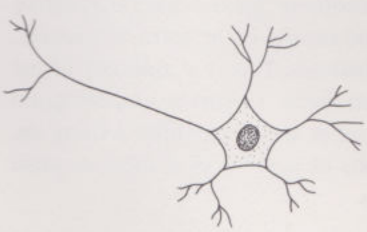
(b) **Cellular structure.** Having looked at the way groups of organisms obtain food, let us now consider the structure of yeast and see how it differs from that of other organisms. You may recall from Section 3 that yeast is a single-celled organism (Figure 1) and that each individual cell looks identical to the others. A number of organisms are single-celled, such as paramecia, which live in water (see Module 4), and bacteria. All these single-celled organisms, including yeast, are too small to be seen without some form of magnification such as a microscope.

The majority of familiar organisms, however, are multicellular—that is, they consist of many cells (you were introduced to this in Modules 5/6). In multicellular organisms cells are of different types. They may have quite strikingly different structures, as regards shape, size and content. For example, a human skin cell (Modules 5/6) is quite different in appearance from a muscle cell (Figure 16a), a cell lining the human gut (Figure 16b), or a human nerve cell (Figure 16c). These cells like that of yeast also contain organelles.

(a)



(b)



(c)

FIGURE 16 Diversity of the shape and size of cells found in humans. (a) a muscle cell; (b) a cell from the lining of the gut; (c) a nerve cell.

One of the consequences of being a larger multicellular organism is that different cells take on different functions. The shape or appearance of human cells is related to the different functions, or work that they carry out. A muscle cell changes shape; a cell lining the gut is protective, but it also plays a very important role in taking into the body, food that has been digested or broken down inside the gut. A nerve cell is very long because it transmits messages along its length to adjoining nerve cells.

(c) **Method of respiration**. Another important comparison that can be made between yeast and other organisms relates to the breakdown of sugar to provide energy—the process of respiration. We might ask whether this process is common to all living organisms? In fact, respiration is universal and occurs within each individual cell of a multicellular organism as well as within cells of single-celled organisms.

The process of respiration is the same in both animal and plant cells. It is the same as aerobic respiration in yeast cells. They need oxygen to assist in the breakdown of sugar. Let us remind ourselves of the equation for aerobic respiration:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy} \qquad (1)$$

□ Compare the process of aerobic respiration, equation (1) with the process of photosynthesis, equation (3) above.

- The process of aerobic respiration is the *reverse* of photosynthesis. Photosynthesis involves the production, by green plants, of sugars and oxygen from carbon dioxide and water, while respiration converts the sugar back to carbon dioxide and water, using up oxygen in the process.

This scientific observation you have just made is an extremely important one. The process of photosynthesis replaces the oxygen in the atmosphere that is used up by the process of respiration.

What is happening during the process of respiration is that the energy locked up in sugar (derived from sunlight) is now released when organisms need it. Like yeast, plants and animals use the released energy to maintain themselves, to grow and to reproduce.

Although we have considered only a limited number of living organisms, life exists in many forms. It has been estimated that the current number of living species on Earth is about 3×10^7. However, all living material has certain features in common, such as cellular structure, and functional properties, such as respiration, that separate it from non-living material.

8.1 PRACTISING SUMMARIZING

The use of notes to summarize the content of a page you are reading was discussed in Section 1, but such notes can also be useful as the best place to start when it is *your* turn to do the writing. A set of brief notes summarizing your knowledge of the topic can provide the framework on which to build your answer to a question. So when you have to write something a set of notes summarizing a passage or topic enables you to hold onto the information in your head, and to relate it to other bits of information or other summaries.

SAQ 4 To get some practice in summarizing, re-read point (a) in Section 8 and try to summarize the information it contains in a single sentence. Now do the same for points (b) and (c), then compare your answers with ours.

Did you notice how this activity helped you to identify the most important information? You might also have noticed that the extra effort you put into writing the summaries helped you to understand the Section better.

SAQ 5 Construct a set of brief notes, based on your reading of Section 8, which you could use to write an account entitled, 'The similarity and differences of living organisms'.

Do not worry if you find this technique of note taking and summarizing difficult. Again it gets easier with practice!

One last point about summaries needs to be made. This Module focused on carrying out an investigation, presenting the results in graphs and interpreting the results. Scientists write up their experimental results in the form of a report. One important element of such a report is an **abstract.** This is a summary of the results and any conclusions you can draw from them. So this is another good reason for learning to summarize. It is easier to write an abstract after writing the rest of the report, but try summarizing the results of your investigation on yeast by answering the following SAQ.

SAQ 6 Write an abstract of the investigation to determine whether temperature affects the rate of gas production in yeast. Write two or three sentences summarizing your results and a sentence giving the conclusions.

9 OVERVIEW

SUMMARY

These are the concepts you have learned about in this Module:

- Organisms may consist either of a single cell (unicellular) or of many cells (multicellular).
- There are many differences between organisms but there are also similarities between them.
- Organisms unlike non-living material can maintain themselves, grow and reproduce. To do this they require energy.
- The process of aerobic respiration requires oxygen to produce energy and involves the breaking down of sugar to carbon dioxide and water.
- The process of anaerobic respiration in yeast produces energy in the absence of oxygen, in which case the sugar is broken down into carbon dioxide and alcohol.
- Green plant cells can photosynthesize: they obtain energy from sunlight to produce sugar from carbon dioxide and water.
- The conversion of chemical compounds that occurs in living processes is brought about by enzymes. These substances are sensitive to temperature.
- The growth of populations of organisms is exponential as long as there is an adequate supply of food.
- Single-celled organisms multiply by the process of cell division.

SKILLS

Now that you have completed this Module you should be able to:

- plot graphs using a suitable scale, label the axes and add a title
- understand how to interpret graphs
- use graphs to establish the relationship between two variables or quantities.

You should also be able to:

- summarize pieces or sections of text
- follow written instructions to carry out an investigation.

To test your understanding of the Module, here are some additional SAQs.

SAQ 7 Turn to Figures 4 and 5 and look at the scale that was chosen to illustrate the results of the two experiments. If these had been the only sets of results would the scales have been the most suitable to choose?

SAQ 8 Try plotting the following points on the set of axes given in Figure 17; remember the form (x,y), or (horizontal value, vertical value):

A(2,2); B(5,3); C(2,3); D(2,6); E(3,7); F(5,7); G(7,2); H(7,8)

Mark each point with an × and with the appropriate letter.

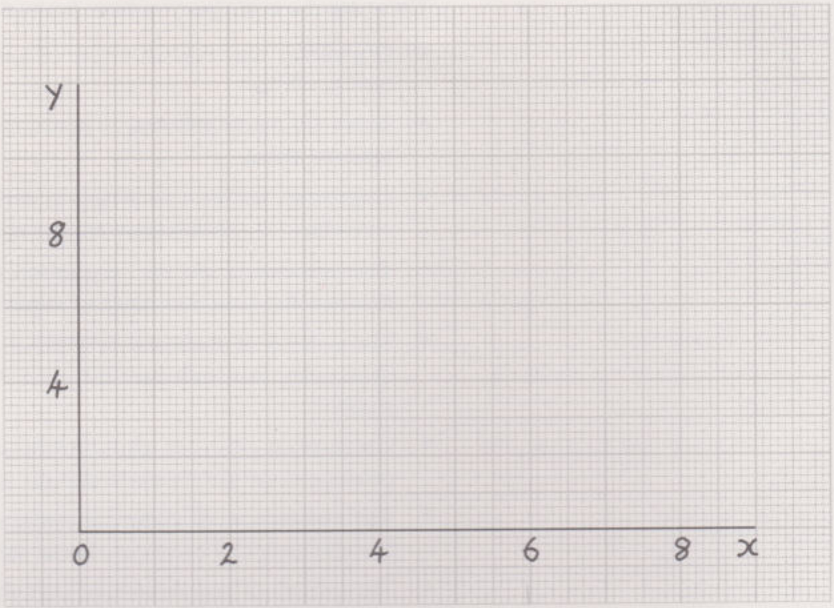


FIGURE 17 For use with SAQ 8.

SAQ 9 Join points AD and AG on the graph that you drew for SAQ 8. Make a point I so that ADIG is a rectangle. What is the horizontal and vertical value of point I?

SAQ 10 Figure 18 shows the increase in size of different parts of the body from birth to physical maturity. (a) Describe the growth of the brain relative to the trunk. (b) Describe the growth of the legs relative to the trunk.

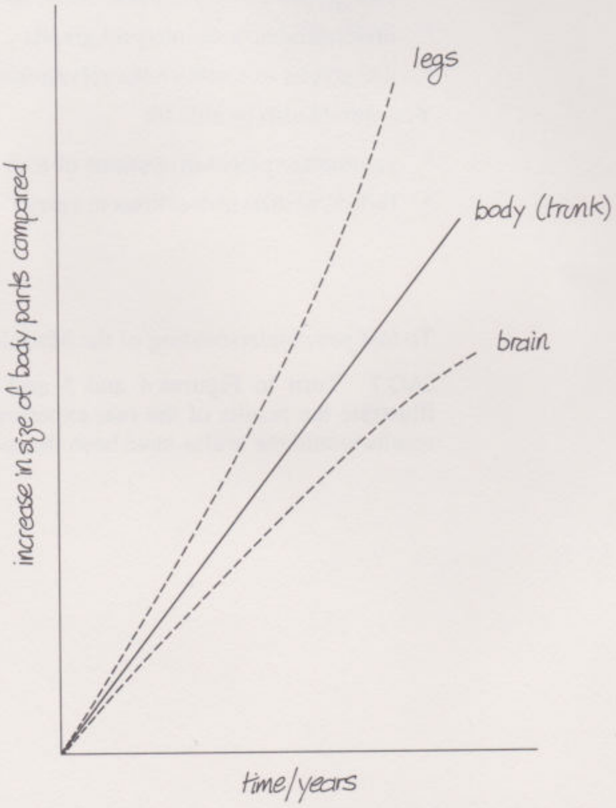


FIGURE 18 Increase in size of different parts of the human body

The next SAQ is about human growth. The shape of the graph does not tell what the increase in size is due to. In humans the high rate of growth of a developing baby in a woman's womb is due to cell multiplication. Interestingly, after birth, although cell division does still occur, growth primarily involves enlargement of existing cells.

SAQ 11 The graph paper shown in Figure 19 is 1 inch graph paper. Plot the values shown in Table 5, taking care with your choice of axes and scale. Remember to label your graph fully.

TABLE 5 Human growth

Age/years	Mass/kg	Age/years	Mass/kg
0 (birth)	3	12	38
2	10	14	48
4	15	16	58
6	20	18	62
8	22	20	63
10	30		

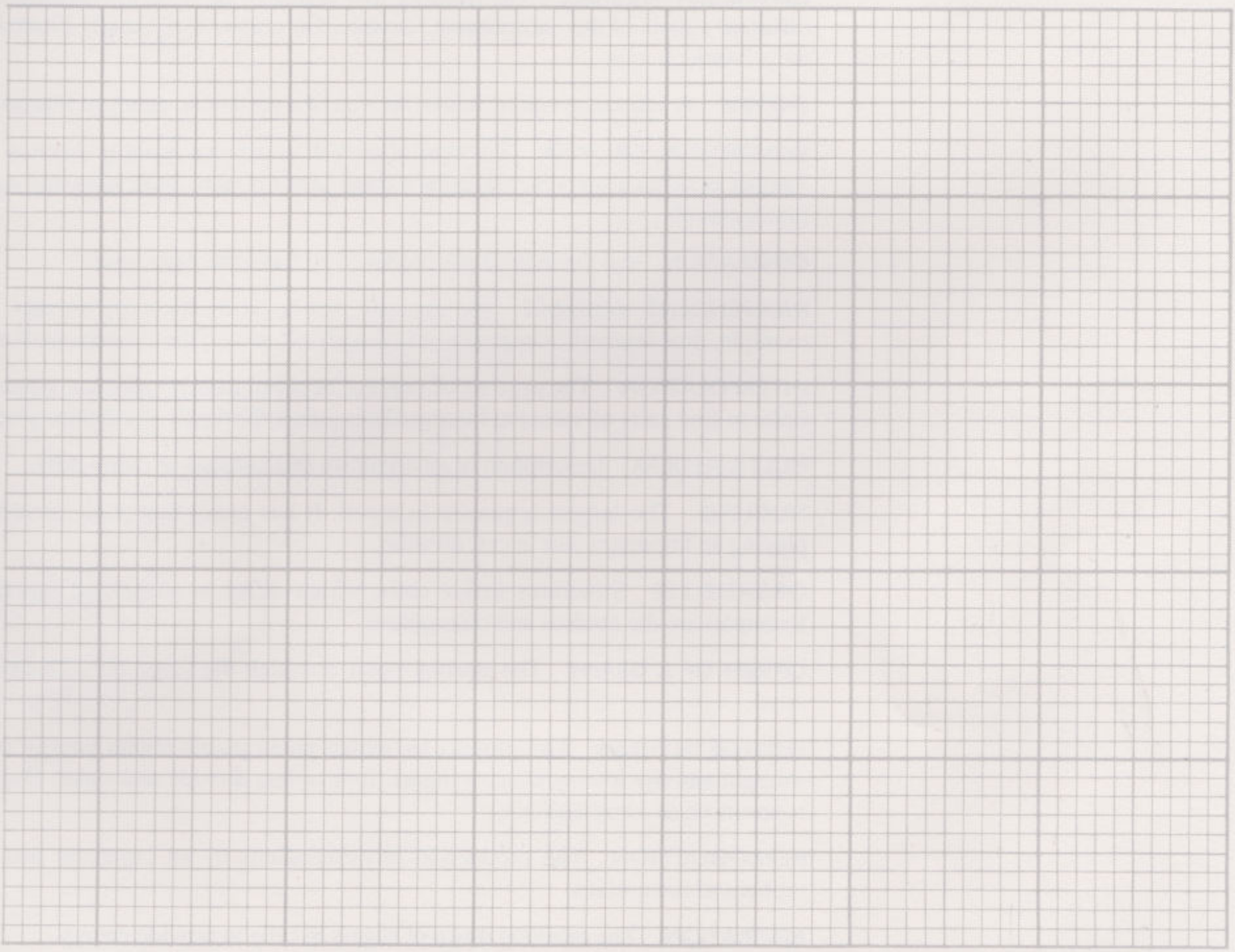


FIGURE 19 For use with SAQ 11.

APPENDIX 1: EXPLANATION OF TERMS USED

As you progress through the Modules, you will meet some of these terms again and learn more about them.

ABSTRACT A summary of the results and conclusions of an investigation which is included in a scientific report.

AEROBIC RESPIRATION The type of respiration in which sugar and oxygen are broken down to carbon dioxide and water, with the release of energy.

ANAEROBIC RESPIRATION The type of respiration that takes place in the absence of oxygen. In the case of yeast, sugar is broken down to carbon dioxide and ethanol, with the release of energy.

AXES OF A GRAPH The pair of reference lines, at right angles to each other, used to locate points on a graph.

CELL DIVISION The splitting of a cell to give two progeny cells.

CHLOROPLASTS The organelles in plant cells in which photosynthesis takes place.

DEPENDENT VARIABLE The quantity that is measured in an investigation for different values of the independent variable. On graphs it is usually plotted on the y (vertical) axis.

ENZYME A substance that increases the rate of a particular chemical reaction.

EXPONENTIAL GROWTH The type of growth in which a quantity (such as the number of cells) always increases by a fixed factor in each successive and equal time interval.

GENERATION All the individuals produced at about the same time.

INDEPENDENT VARIABLE The quantity that is set by the experimenter, for example, time intervals. On graphs it is usually plotted on the x (horizontal) axis.

INTERPOLATION The process of reading between data points on a graph, in order to find pairs of values at intermediates points for the two quantities plotted.

MULTICELLULAR Description of an organism that consists of many cells.

NUCLEUS The largest organelle in a cell. It has many functions, including playing an important part in cell division.

ORGANELLES Structures inside cells, which differ in shape and function. Examples are the nucleus and chloroplasts.

ORIGIN OF A GRAPH The starting-point at which the value on each axis is zero.

PHOTOSYNTHESIS The process by which green plants obtain energy from sunlight and use it to synthesize sugars from carbon dioxide and water. Oxygen is produced as a consequence.

REPRODUCTION The production of descendants by an organism that are replicas of themselves.

RESPIRATION The breaking down of sugars in cells to provide energy.

SCALE (ON THE AXIS OF A GRAPH) A graduated line indicating the length used to represent a different unit.

VARIABLE (OR QUANTITY) Something that has the characteristic of being variable. Examples include time, volume and length.

APPENDIX 2: CONVERSION TABLE FOR VOLUME (approximate figures)

Imperial	Metric cm^3
2 fl oz	60
5 fl oz ($\frac{1}{4}$ pint)	150
$\frac{1}{2}$ pint	275
$\frac{3}{4}$ pint	425
1 pint	570
$1\frac{3}{4}$ pints	1 000

APPENDIX 3: SPECIMEN GRAPH FOR GUIDED EXERCISE 1

The completed Figure 9 is shown in Figure 20 using our data.

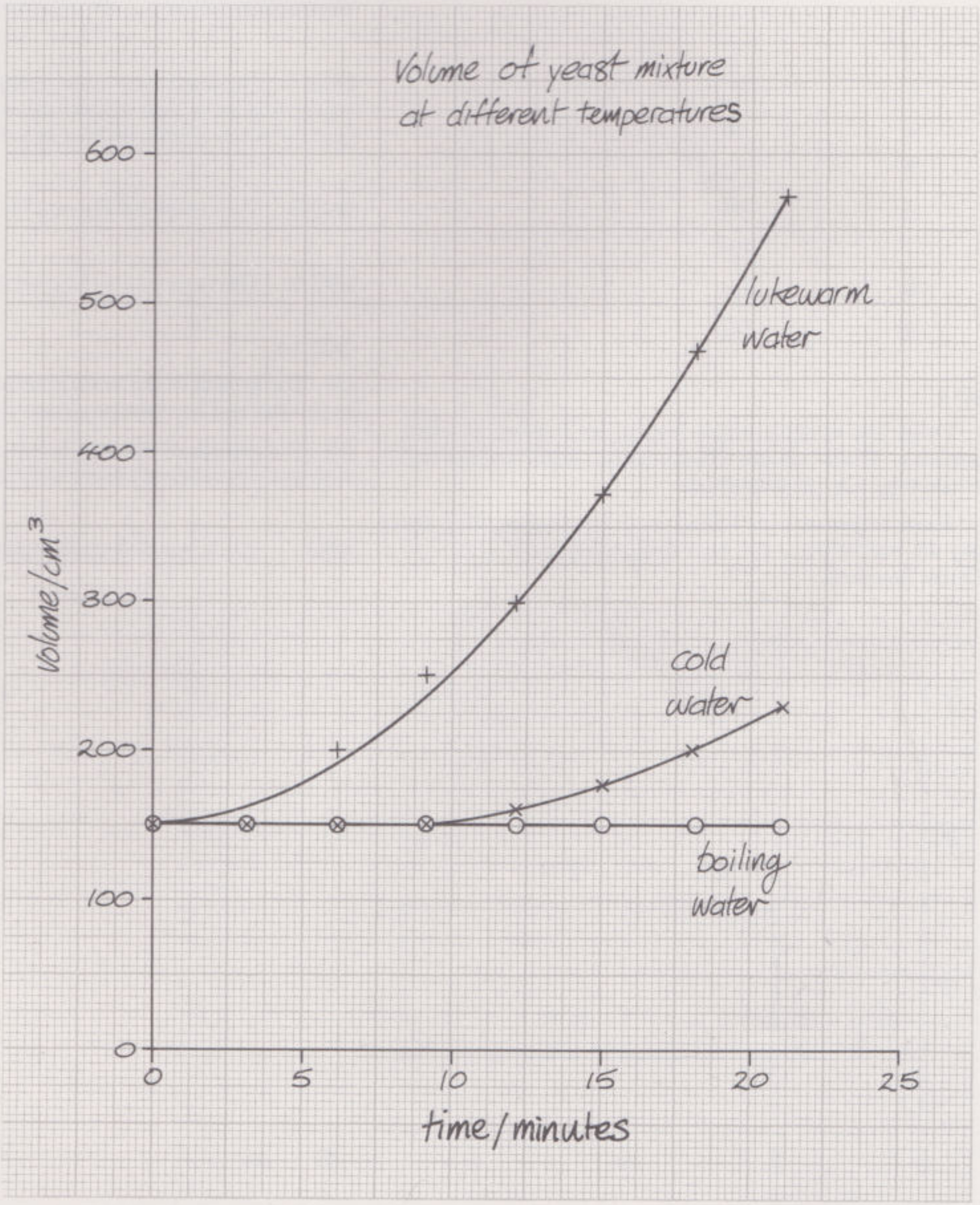


FIGURE 20 Completed Figure 9 using our results.

SAQ ANSWERS AND COMMENTS

SAQ 1 The size of each small square is 1.0mm by 1.0mm.

SAQ 2 Here is one possible answer. Yours might be quite different, but the scientific points included should be similar.

Yeast obtains energy by means of the breakdown of sugar. This process of respiration can occur in the presence of oxygen (aerobic) and in the absence of oxygen (anaerobic). The process is assisted by enzymes, which work best at a temperature of about 37°C. They work more slowly at cool temperatures, such as 10°C, and are destroyed at high temperatures.

SAQ 3 Table 7 is the completed Table 4, showing the number of yeast cells after each cycle of growth and reproduction up to the ninth cycle.

TABLE 7 Completed Table 4

Number of cycles of growth and reproduction	Number of yeast cells
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512

SAQ 4

(a) Fungi and animals obtain energy by feeding on other organisms, whereas plants obtain energy from sunlight and produce sugars by photosynthesis

(b) Some organisms including yeast are single-celled but many are multicellular and have different types of cells with different functions.

(c) Organisms obtain energy by means of aerobic respiration but a few can do so by anaerobic respiration.

SAQ 5 *Similarities* Organisms are made up of cells; they break down sugar and other food compounds to obtain energy; they break down chemical compounds and build different chemical compounds assisted by enzymes.

Differences Some organisms are single-celled others are multicellular; plants obtain energy from sunlight and produce their own sugars by means of photosynthesis, whereas animals and fungi live on other organisms. Most organisms respire aerobically although some can respire anaerobically.

A set of notes such as these could form the basis for your account entitled, 'The uniformity and diversity of living organisms'.

SAQ 6 Different volumes of gas, as measured by the quantity of froth, were produced by yeast at different temperatures. A few bubbles were produced in cold water, large quantities in tepid water and no bubbles in boiling water. Temperature affects the quantity of gas produced.

SAQ 7 The horizontal scale is appropriate but the vertical scale could have been reduced considerably, using 0–300 cm^3 over the whole length, without loss of information.

SAQ 8 The completed Figure 17 is given in Figure 21.

SAQ 9 The value of I is (7,6); see Figure 21.

SAQ 10

(a) The growth of the brain relative to the trunk is slower to begin with and becomes progressively slower with time.

(b) The growth of the legs is faster than the trunk to begin with and gets relatively faster with time.

SAQ 11 The completed graph is given in Figure 22.

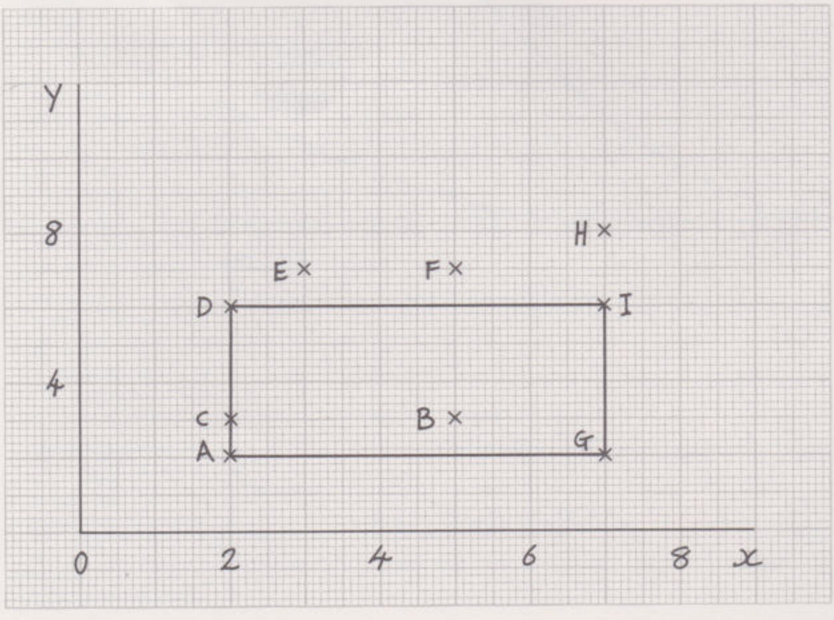


FIGURE 21 Completed Figure 17 for SAQs 8 and 9.

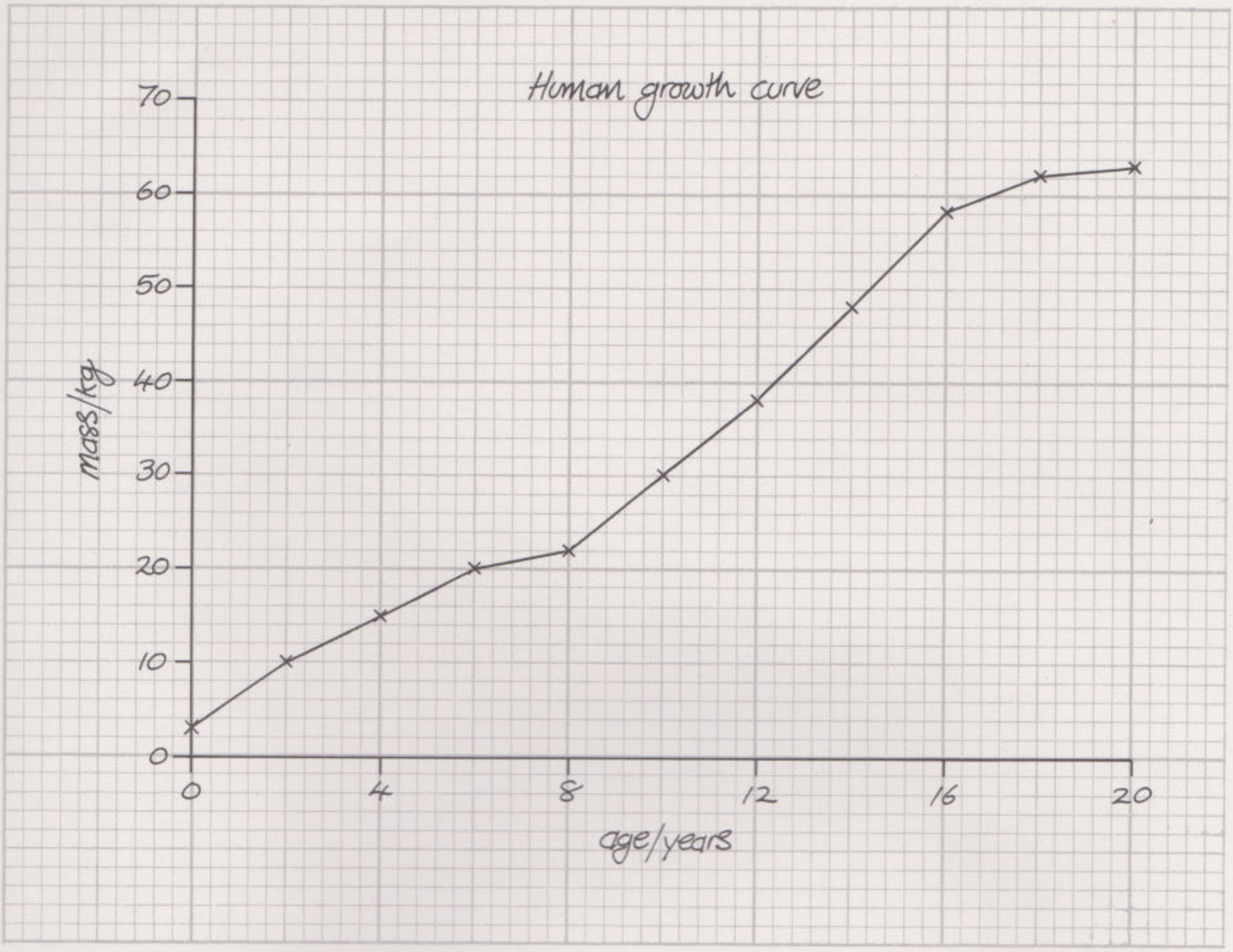


FIGURE 22 Completed Figure 19 for SAQ 11.